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WARRANTY/CANNIBALIZATION ISSUES, DISRUPTIVE FORCES IN THE PRODUCTION AND MAINTAINABILITY OF THE E-2C AIRCRAFT

by

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June 2000

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This thesis analyzes manufactures' warranties and cannibalization issues as they affect the maintainability on the E-2C aircraft. The analysis includes cannibalization structures, reasons why squadrons cannibalize, alternatives to cannibalization, cannibalization issues that affect maintenance personnel morale, and the disruptive effects of manufacturers' warranties to the fleet. The research identified that introducing production aircraft to the fleet without proper logistical support increases aircraft cannibalization and decreases maintainability. Cannibalization should not be used to increase aircraft readiness, since it doubles maintenance man-hours and depletes resources. Inconsistent Aviation Maintenance and Material Management (AV-3M) data contributes to aircraft cannibalization. An acquisition strategy that identifies logistics problems early will give the logistician an opportunity to decrease cannibalization.

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WARRANTY/CANNIBALIZATION ISSUES, DISRUPTIVE FORCES IN THE PRODUCTION AND MAINTAINABILITY OF THE E-2C AIRCRAFT

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The research identified that introducing production aircraft to the fleet without proper logistical support increases aircraft cannibalization and decreases maintainability. Cannibalization should not be used to increase aircraft readiness, since it doubles maintenance man-hours and depletes resources. Inconsistent Aviation Maintenance and Material Management (AV-3M) data contributes to aircraft cannibalization. An acquisition strategy that identifies logistics problems early will give the logistician an opportunity to decrease cannibalization.

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I. INTRODUCTION

A. BACKGROUND

The E-2B aircraft was first introduced in 1966 as a replacement for the aging piston engine driven E-1B Tracer aircraft built by the former Grumman Aircraft Corporation. The E-2B was the first variant of the E-1B built in the early 1960's as an Airborne Early Warning (AEW) platform to detect and identify enemy aircraft hundreds of miles from the Battle Group. The E-2B remained in the fleet from 1966-1973, until replaced by the E-2C. Although the E-2 has gone through many variations throughout its life, the aircraft and airframe remain virtually the same.

The E-2C aircraft entered U.S. Navy service with Airborne Early Warning Squadron 123 at Naval Air Station (NAS) Norfolk, Virginia in November 1973. During the 1980's, the E-2C aircraft continued to incorporate improvements to keep pace with technology advances and the changing operational environment. In 1984, the original E-2C model was succeeded by a newer version, with a stronger radar and avionics package. That model was known as the Group 0 configuration. In 1988, the Group I version was introduced, featuring an upgraded T56-A-427 engine. The new

engine eliminated operating restrictions imposed by the aircraft's growing gross weight after incorporating new systems. In addition, Group I provided anti-jam antennas, cross-bleed engine starting, and an updated radar with a high-speed processor that doubled its capacity. December 1991 marked the first deliveries of the current, Group II version to the Pacific Fleet. Their improved radar alleviated saturation and tracking overload with additional avionics systems that made it superior to the Group I version. The next generation E-2C aircraft, the Hawkeye 2000, is undergoing flight tests at Paxtuent River, Maryland and should be ready for introduction into the fleet by the year 2001.

The E-2C aircraft is unique because many of the parts used to maintain operational availability on the first version (Group 0) can also be used to maintain the latest version (Group II). The ability to integrate components should create an abundance of parts, but this is not the case. Many spare parts are not readily available in the supply system. This problem has contributed to a high cannibalization rate in the E-2C. Cannibalization, as defined in this case, is replacing a defective part or component of one system with an in-use part or component

from another system. This procedure creates three times the work for the maintenance technician, thereby wasting valuable assets. Manufacturers' warranties contribute to high cannibalization rates because Aircraft Intermediate Maintenance Department (AIMD) technicians are not authorized to work on warranty items.

This thesis will examine the difficulties in maintaining the E-2C aircraft for operational use and reasons the cannibalization rates continue to soar, with special attention to the advantages and disadvantages of manufacturers' warranties.

B. PURPOSE

This thesis analytically evaluates problems associated with manufacturers' warranties and aircraft cannibalization. In this era of downsizing and program scrutiny within the Department of Defense, it has become increasingly important to use resources efficiently. This thesis will use the E-2C aircraft to examine personnel, monetary, and readiness costs, while reviewing the Navy's operation and maintenance procedures associated with aircraft cannibalization and warranty issues. Finally, the thesis will explore and recommend changes that can be

implemented to reduce the burden and frustrations associated with supporting multiple E-2C configurations.

C. RESEARCH QUESTION

The primary research question is: What are the impacts of manufacturers' warranties and aircraft cannibalization on the maintainability of the E-2C aircraft?

D. SCOPE

The thesis will analyze cannibalization, warranty issues and their effect on the E-2C aircraft. The analysis includes cannibalization procedures for both the Pacific and Atlantic fleets; why squadrons cannibalize; alternatives to cannibalization; morale issues that cannibalization causes among maintenance personnel; effects of manufacturers' warranties and why they are potentially disruptive to the fleet; and monetary costs involved with the use of a limited military budget. The thesis will conclude with recommendations to improve management of aircraft maintenance and make warranty procedures more cost-effective and responsive to readiness requirements.

E. METHODOLOGY

This thesis will address problems presented to the fleet using a thorough literature review of pertinent aviation maintenance records. Data will cover the past

three years of the E-2C aircraft with specific emphasis on the last two years. Information, will also be collected from various reports, such as Naval Aviation Logistics Data Analysis (NALDA); Aviation Maintenance Readiness Reports (AMRR); Commander, Airborne Early Warning Wing, Atlantic/Pacific Fleet (COMAEWWINGLANT/PAC) daily status reports; Naval Aviation Depots (NADEP) North Island, California, and St. Augestine, Florida, Phased Depot Maintenance (PDM) reports. Data will also include personal and telephone interviews with the E-2C item manager, Navy Inventory Control Point (NAVICP) item manager, and maintenance officers assigned to COMAEWWINGLANT/PAC.

The overall goal of this thesis is to collect relevant data, analyze cannibalization and warranty issues throughout the E-2 community, and implement a plan to reduce or resolve any concerns that arise.

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II. WARRANTIES IN NAVAL AVIATION MAINTENANCE

A. POLICY

Eleanor R. Spector, Director of Defense Procurement, has recently rewritten Office of the Secretary of Defense (OSD) policy concerning warranties for major system acquisitions. While OSD establishes overall policy for warranties, each military service is responsible for tailoring that policy and implementing it within their respective organization.

The Naval Air Systems Command (NAVAIR) has established the warranty guide for the naval aviation community. This guide focuses on logistics policy and processes for the aviation community. It is NAVAIR policy to pursue cost-effective warranties on all procurements. The NAVAIR Program Managers (PMs) are responsible for developing and including appropriate warranty provisions in contract solicitations. Integrated product teams are required when determining warranty requirements. Additionally, warranty periods (the duration of warranty coverage under contract), must be clearly stated in the solicitation. Warranty clauses should explain what benefit the Government derives

(e.g., improvement in fleet readiness and mission effectiveness).

A cost/benefit analysis is required to justify using a warranty. If a warranty can not be supported by a cost/benefit analysis, then the program manager should not invest in a warranty. In other words, a warranty provision should only be included in a contract if it makes good business sense and is executable in the fleet. The warranty is the exception rather than the legal requirement. This is a new policy change that was promulgated by the Director of Defense Procurements and is reflected in the NAVAIR warranty guide. [Warranty Guide, 1998] The purpose of the policy amendment was to eliminate warranty clauses that do not add value or are not executable in the fleet. There must be a benefit to the Government in order to include warranty provisions in the contract.

A warranty is a contractor's promise or affirmation given to the Government regarding the nature, usefulness, or condition of the supplies or the performance of service furnished under the contract. A warranty should protect the Government (and possibly the contractor in the case of vendor-provided items) against defective items and services, promoting quality performance throughout the life

of the warranty. A warranty provides a contractual right to correct defects. Life cycle cost estimates must support warranty cost/benefit analysis efforts. Warranty cost may increase or decrease a system's life cycle costs. The benefits to be gained from a warranty must be proportionate to the Government's cost of the warranty. The warranty must be cost-effective to the Government; if it is not; the warranty should not be purchased.

Several types of warranties are covered under the NAVAIR warranty guide; however, the researcher will only discuss two that continue to raise concern throughout naval aviation organizational and intermediate levels of maintenance: reliability, and reliability and maintainability warranties. The objective of reliability warranties is to reduce failures during intervals between overhauls. The contract contains an overhaul interval for specified components and identifies the remedy required when components experience specified failures before the next overhaul. It applies to critical, potentially high failure rate components under a fixed-price contract. If a component does not measure up to its expected reliability, it must be replaced before the expected point of wearout to avoid premature failures. This is very disruptive to the

fleet because reliability warranties require that the failed components be returned to the manufacturer for repair. The effects on the fleet are discussed later in this thesis.

Reliability and maintainability warranties motivate the producer to increase equipment reliability, while reducing the mean corrective maintenance time (MCMT). With such a warranty arrangement, the contract contains a mean time between failure (MTBF) guarantee for specified components and a maintainability clause specifying MCMT. The contract identifies remedies when MTBF or field maintainability specifications are not met. This warranty arrangement applies to critical, potentially high-failure rate installed components under a fixed-price contract. This warranty has the most detrimental effect on life cycle costs of any warranty concerning logistics. If the MTBF of a component is not accurate, the Navy will either over or under obligate funds to purchase spare components. This problem continues to demoralize the fleet and will be discussed later in this thesis.

B. PRACTICES

NAVAIR is the cognizant activity for E-2C aircraft warranty purchases. NAVAIR is responsible for administering

warranties for new E-2C production aircraft as they are introduced into the fleet. In the E-2C community, there are many configurations of the aircraft and each configuration (Group 0 - Group II) comes with its own set of warranty provisions. This confuses supply and maintenance personnel in the fleet.

Lisa Sanders, NAVAIR production integrated process team manager for the E-2C, stated in an interview that aircraft presently in the fleet have only a small number of warranty issues at this time, none of which are classified as major concerns. NAVAIR expects the next wave of warranty issues for the E-2C to occur in Fiscal Year 01, when introducing the next generation E-2C aircraft, the Hawkeye 2000.

Lisa Sanders also suggested that the problems that the fleet is experiencing may have resulted from a communications breakdown. NAVAIR does not grasp the magnitude of the current warranty problem, thinking that this particular configuration of the E-2C was introduced to the fleet over ten years ago. In NAVAIR'S eyes, all production warranties of concern have been identified and corrected. The fleet, however, continues to have problems because initial warranty issues are not resolved. This

aircraft has many configurations and multiple warranties that are still of concern. The discrepancies were not corrected and fixes to the problems were not pursued.

Two examples of how manufacturers' warranties can affect the fleet, are offered below. The first example is "by the book," or step-by-step, what is expected under a reliability and maintainability warranty according to NAVAIR's warranty guide. The second example demonstrates what happens far too often in the fleet when warranties fail to meet expectations.

Example One: A production aircraft comes from the factory and is in use in the fleet. An avionics box that controls the radar has a MTBF of 2000 operating hours; the box should average 2000 operating hours before it fails. However, the box fails at 500 operating hours.

The box is removed by maintenance technicians and turned in to supply for a replacement. The box (under warranty to last 2000 operating hours) is shipped to the contractor for repair where data is taken and given to the type wing, program manager, supply activity and various other entities to record the box's history. The recorded data is used by the contractor to determine why the box performed to only one forth of the prescribed reliability.

If the box failure represents a simple problem and requires a minor adjustment, the box is repaired and sent back to the supply center for reissue. If the same box fails at a premature rate in another aircraft, the contractor must repair all failures and may implement a no-cost engineering change proposal (ECP) for reliability and maintainability (R&M) improvements. MTBF is adjusted accordingly. When a newly configured aircraft receives the same black box, it should have the new modifications. This reflects how the system is supposed to work.

Example Two: Six-production aircraft join the fleet at the same time and four of them are assigned to a deploying squadron. The squadron is scheduled for an overseas deployment within six months after accepting the new aircraft. After completing battle group work ups (training exercises), the squadron deploys. The deploying carrier is set up like all other aircraft carriers in the fleet, with three E-2C aircraft positioned on the flight deck and one aircraft located in the hanger bay because of the space constraints.

Three weeks into the deployment, two of the four aircraft experience trouble with an avionics box that controls the radar. The non-functional boxes render each

radar inoperable, downing both aircraft. The E-2C's primary mission is to use its radar to detect enemy aircraft approaching the battle group. The non-functional boxes are replaced with on-hand assets drawn from supply. Supply then ships the non-functional boxes to the contractor for repair because they are still under warranty.

The turnaround time to repair both boxes is 45 days, in addition to the time it will take the boxes to get back out to the deployed ship. One week later, another box is non-functional on one of the flight deck aircraft and must be replaced; however, there are no more boxes in the ship's Aviation Consolidated Allowance List (AVCAL). This means the squadron is down to three operational aircraft. The ship is about to conduct 24-hour flight operations and needs all three mission capable aircraft on the flight deck. The ship cannot easily bring the good aircraft from the hanger because it is buried in the corner surrounded by other aircraft; it would be difficult to move without re-spotting the entire hanger bay. What will the squadron do?

The squadron will take the known good box from the aircraft in the hanger and install it in the aircraft on the flight deck leaving, a hole (that is, a missing component) in the hanger aircraft. This is what the Navy

calls a cannibalization action. Cannibalizations will be discussed thoroughly in chapter three. The third box that went bad is not sent off the ship. It is inducted into Aircraft Intermediate Maintenance Department (AIMD) located on the ship and a maintenance technician will attempt to repair the box. This maintenance action will void the warranty and cause the Navy to lose thousands of dollars.

The second example happens all too often, because warranty provisions are written from the perspective of the buyer, not the fleet maintainer. Many times the MTBF of a component or part is incorrect and is actually only a fraction of the contractor's engineering prediction. The inventory of spare parts on each ship, determined by the AVCAL, is based on MTBF of components and the budgeted funds available to buy them. This means the Navy will only purchase a fraction of the spares actually needed. This leads to cannibalization, as described in Example 2 above.

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III. CANNIBALIZATION IN NAVAL AVIATION MAINTENANCE

A. POLICY

Cannibalization in Naval Aviation can be simply defined as removing a serviceable component from one aircraft and installing it in another aircraft to restore it to a serviceable condition. In the 1970s, The Chief of Naval Operations (CNO) recognized the wasted man-hours involved in cannibalization. The CNO continues to express great concern over the aircraft maintenance man-hours wasted every time a maintenance technician cannibalizes a needed component. These wasted man-hours amount to double the work. That is, every cannibalization requires dual component removals and dual component installations.

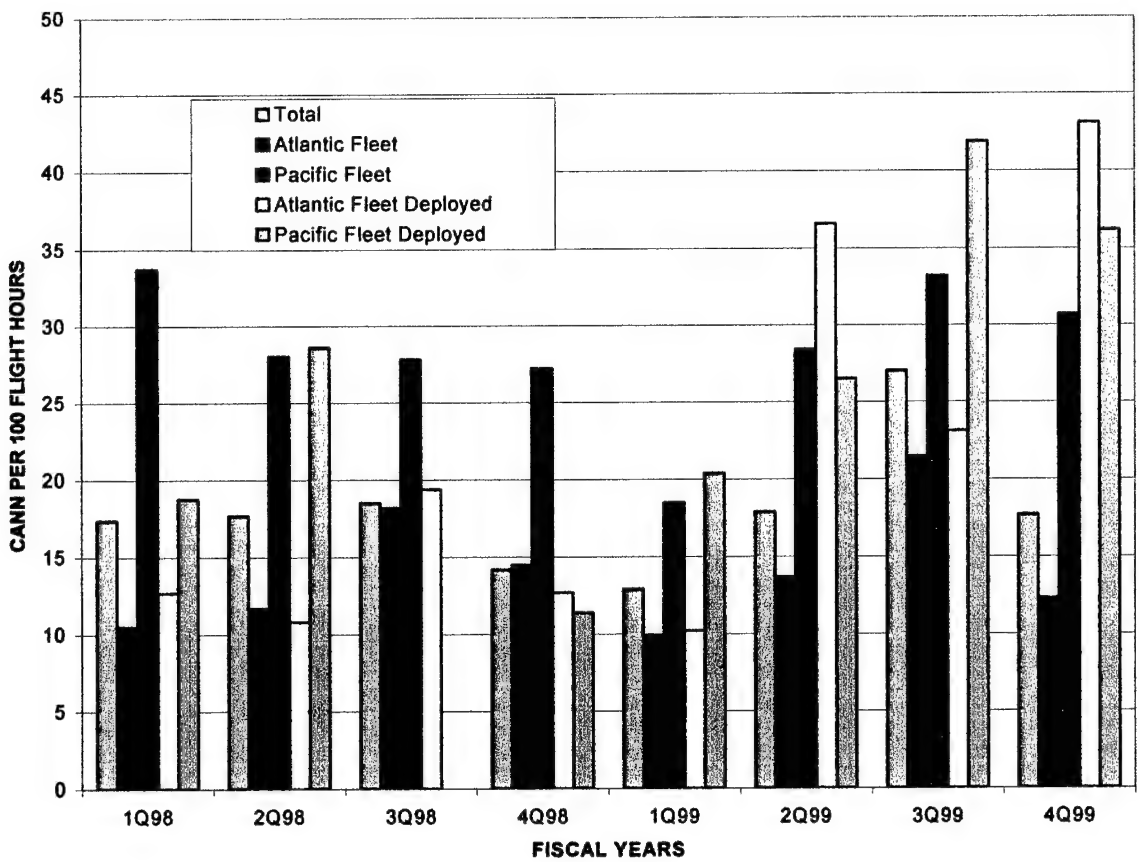
OPNAVINST 4790.2G states that "cannibalization with few exceptions, is a manifestation of a logistic or maintenance support system failure." It further states that cannibalization reduces morale and worsens Non Mission Capable Supply (NMCS), and Partially Mission Capable Supply (PMCS) readiness conditions. Type Commanders direct all commands under their authority to keep cannibalizations to a minimum. This applies to the Atlantic and Pacific Fleets. (CNO MSG, 1979)

The E-2C aircraft is not single sited; therefore, it receives direction from Commander, Naval Air Force Atlantic/Pacific Fleet (CNAL/CNAP), respectively, concerning cannibalization actions. Each coast is responsible for producing their own cannibalization guidance for their assigned E-2C aircraft.

Cannibalizations are historically measured in one of two ways: the number of cannibalizations per 100 flight hours, and the total number of items cannibalized in a specified period (i.e. cannibalizations per month, quarter or year).

Figure 1 displays cannibalizations per 100 flight hours, per aircraft deployed Atlantic/Pacific fleet and total E-2C aircraft, from first quarter fiscal year 1998 to fourth quarter fiscal year 1999. The data shows increasing cannibalizations during the last three-quarters of fiscal year 1999. The increase reflects the addition of new E-2C Group II aircraft to the Atlantic fleet. New aircraft would normally decrease cannibalizations. However, the new aircraft encountered supply shortages, requiring cannibalizations of other E-2C aircraft to maintain minimum readiness throughout the fleet.

Figure 2 provides a better picture of the cannibalization trends presented in Figure 1. The chart compares the deployed Atlantic and Pacific fleet cannibalization numbers during Fiscal years 1998-99. The Atlantic fleet spike in August of 1999 represented a surge in operational commitments for the E2C aircraft during that period.



Data not available for Pacific Fleet Deployed third quarter 1998

Figure 1. E-2C Cannibalizations per 100 Flight Hour

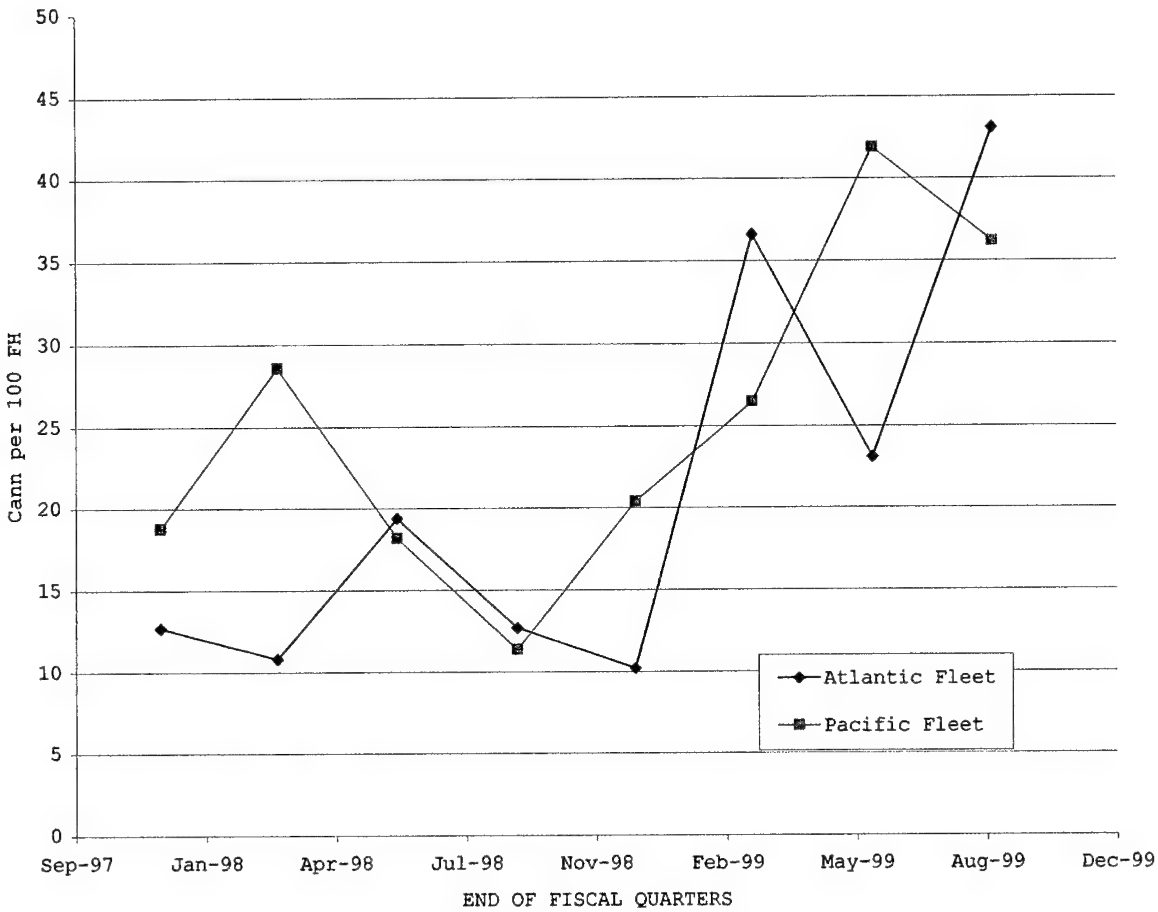


Figure 2. Cannibalizations per 100 Flight Hour Deployed

Functional type wings on each coast establish cannibalization procedures for their respective squadrons. Each type wing, although very similar in structure, administers their cannibalization policy differently. The overall policy for both coasts continues to be reducing cannibalization when at all possible.

B. SQUADRON CANNIBALIZATION

The reasons why aircraft squadrons cannibalize vary. There are as many different reasons to cannibalize as there are aircraft squadrons and maintenance managers. Each squadron works in a different management environment with different constraints as well as different goals to fulfill. Understanding what cannibalization is and why cannibalization occurs helps determine how to measure its overall impact on aviation squadrons.

1. Maintenance Readiness

Readiness is measured against a 24-hour day and a 30-day month, or a total of 720 hours. Each time the aircraft is not ready for flight (not mission capable), the time it spends in a not ready status is subtracted from 720 hours to get actual ready time. The readiness measure is a percentage figure, which is obtained by calculating the actual ready time and dividing it by 720 hours. The CNO has

set a readiness goal for the E-2C aircraft of 70 percent (5442.4M).

Aircraft readiness is so important to the Navy that it has become a determining factor in the career success or failure of maintenance managers and commanding officers. Aircraft may not be ready for flight for many reasons, most of which are internal to the squadron; but it is much easier to blame a supporting supply activity for lack of readiness than to admit to the world that internal problems are the primary reasons impacting readiness. To achieve the 70 percent readiness goal, an aircraft must be mission capable for 504 hours each month. Now with this goal in mind, cannibalization as it applies to maintenance readiness can be explained.

The typical squadron maintenance crew, while shore-based, works in two eight-hour shifts, five days a week (1/3 to 1/2 of all E-2C squadrons are shore-based at any given time). This means, little or no maintenance is performed on most weekends. Assuming a four-weekend month, 192 hours of readiness time is accumulated over the four weekends. In other words, 38 percent of the 504 hours required to meet CNO standards occurs during a time in which no maintenance is performed. Add in the eight hours

a day that a two-shift workforce does not cover, and time without maintenance increases to 73 percent of the 504 hours necessary to reach CNO standards.

These figures make it very profitable in terms of readiness to cannibalize on Fridays and during the second shift on weekdays, even if the aircraft is not needed for the next day's flight schedule. By cannibalizing from other aircraft and consolidating material shortages, the negative effects of supply response times and backorders are discounted. All that needs to be done is to order a part, then cannibalize. Why wait on supply system response or risk a not-in-stock situation when the required readiness can be achieved through cannibalization? By picking and choosing cannibalization periods, readiness can be maximized at the expense of a few extra man-hours. This policy consolidates NMCS to the minimum number of aircraft, avoids supply response delays, and maximizes readiness for the squadron commanding officer. (Myette, 1981)

This policy improves the readiness statistics. However, it obscures a real problem that we are having in naval aviation and the E-2C community: shortages of spare parts. The community has been doing business this way to protect itself against the backlash of being unable to

accomplish CNO goals outright. This common practice has contributed to our existing cannibalization dilemma.

2. Material Shortages

The first and probably the most obvious reason for squadron-level cannibalization is a material shortage where the local supply system simply does not have a replacement asset. In this case, the squadron level maintenance manager has no choice but cannibalization to restore the aircraft to a mission capable status.

In the case of a material shortage for a replacement asset that cannot be cannibalized (i.e., an o-ring seal for a hydraulic actuator), the maintenance manager's only alternative is to wait for a replacement asset. However, that aircraft can then become a cannibalization source for other assets.

Under the Naval Aviation Maintenance Program (NAMP), supply shortages are measured by a not mission capable supply rate. This rate is expressed as percent impact on aircraft readiness (OPNAV 4790.2G, 1998). Aircraft readiness is obtained by adding the hours in a month that an aircraft is ready for flight (mission capable) and dividing that total by 720 hours, the number of hours in a 30-day month. For example, if an aircraft was mission

capable for 600 hours in a month, its readiness would be 600 divided by 720, or 83.3 percent readiness.

Not mission capable supply is computed by summing all the hours in a month that an aircraft is not ready for flight (not mission capable) due to material shortages and dividing that value by 720 hours per 30 day month. For example, if the sum of NMCS hours was 200, then the NMCS rate would be 200 divided by 720 or 27.7 percent. If NMCS drives cannibalization, then squadron level cannibalization should vary as a function of material shortages.

Material shortages will drive an individual decision to cannibalize, but do not account for overall cannibalization rates. Squadron level maintenance managers consolidate unfilled supply requirements to as few aircraft as possible, to maximize readiness (Myette, 1981). This shift is assumed true because no one would cannibalize a part if a replacement asset were available. Would they?

Actually, this last statement is not entirely correct; 30 to 50 percent of the cannibalizations in the fleet are for convenience. The assets are in the system, but the maintenance managers decide that it is faster to pull the needed parts or components from another aircraft. This leads to the second reason for cannibalization, having a

supply asset but not being able to issue the asset to the squadron in a timely manner.

3. Supply Response Time

Today's aircraft carrier environment requires aircraft maintenance managers to launch aircraft in a 20-30 minute launch cycle. The time between completing aircraft recovery and the next launch sequence of that aircraft is, at most, 30 minutes. A replacement component that takes more than 30 minutes to deliver is of little use to a maintenance manager for that launch. Even though a local supply activity could be 100 percent effective in meeting the CNO'S goal of one hour supply response time, that time allowance may not come close to meeting the supported squadron's material needs. Many maintenance managers have directed a component cannibalized before ordering a replacement component simply because the component was needed "now," and not "one hour from now." (Myette, 1981)

4. Operational Commitments

Many type commanders view operational commitments as the only valid reason for cannibalization. After all, if the aircraft is not needed to meet the flight schedule, why should maintenance technicians expend double maintenance man-hours just to achieve readiness? This view says,

"Cannibalize when operational commitments require it and allow the supply system to react all other times." The CNO also directs that operational commitments are the only valid reason for cannibalization in his instructions to squadron commanding officers. Unfortunately, the CNO still requires 70 percent readiness.

Squadron commanding officers have so many top priorities that they can only hope to maintain the status quo. Their operating rationale is that if readiness is 70 percent, all operational commitments are met and squadron personnel are relatively happy; to meet the readiness goal, no one would argue with the associated cannibalization activity. (Myette, 1981)

The exception: those squadron commanding officers that have lost aircrew because of a cannibalization action that went bad. Cannibalization discussions typically presume that actions are performed smoothly with no problems. Most of the time that is the case. However, when a part is cannibalized, when the part is needed "now." The maintenance technician may be rushed and inadvertently damage the part or miss a step that can cause a catastrophic failure in the air. In addition, double maintenance activity doubles the possibility of a

maintenance mistake. This is an area that all affected parties must consider, when resorting to cannibalization as a supply option.

5. Avoiding the Risk of Stock Out or Missed Sortie

The supply system goal, as set out in the NAMP, is to deliver 90 percent of all squadron issue-group-one material demanded in one hour. Issue-group-one material is that material that makes an aircraft not mission capable or reduced mission capable. This means that, if a supporting supply activity reaches the established goal, ten percent of the time some period greater than one hour, and in some cases weeks, will be required to deliver the additional issue-group-one material. (Myette, 1981)

In the case of the E-2C aircraft, this 90 percent goal has never been achieved Navy-wide. The E-2C has averaged 67 percent for the last 12 months. The maintenance manager can risk ordering a part and waiting for it to be delivered, knowing that the order will not be filled within one hour 33 percent of the time on average; or cannibalize a sure thing and not miss a scheduled flight. Many maintenance managers view cannibalization as risk avoidance in its purest form.

6. Troubleshooting a Complex Aircraft

Very few maintenance managers would argue against the statement that naval aircraft have become increasingly complex with each generation. Training demands on new maintenance technicians are far greater than the requirements placed on past personnel. To minimize the adverse impact on maintenance and troubleshooting skills, modern aircraft, such as the E-2C, rely heavily on built-in-test (BIT) troubleshooting features. BIT simply tells the maintenance person what is wrong with the system and which component or components have failed.

This system works well, most of the time, unless the BIT feature fails or a failure is outside the BIT diagnostic capability. In the latter case, many error-free components may be changed before a fault is corrected. Removing error-free components by a squadron-level maintenance department is monitored by the supporting intermediate maintenance activity. This monitoring allows intermediate maintenance managers to alert squadron-level maintenance managers of BIT problems or faulty maintenance personnel training.

Squadron-level maintenance managers and technicians are caught between a failed BIT system or troubleshooter

training system and an intermediate maintenance activity that monitors error-free component removal. To avoid this dilemma, the maintenance technician uses a known good system from another aircraft to troubleshoot the suspect system. Simply put, the maintenance manager directs the technicians to cannibalize a good aircraft to fault isolate a bad aircraft.

This type of cannibalization hides poor troubleshooting performances from the intermediate maintenance activity and perpetuates marginal BIT system features. By cannibalizing a good aircraft, to fault isolate a bad aircraft, squadron level maintenance managers minimize their error free removal percentages at the cost of a few extra man-hours. If squadron-level maintenance managers viewed error free removal reporting by the intermediate maintenance activity as indicating possible training or BIT system problems, rather than indicating poor maintenance management ability, then cannibalization for troubleshooting would be reduced. (Myette, 1981)

C. TYPE WING PRACTICES

The Atlantic and Pacific fleet type wing policy on cannibalization is to direct squadrons to cannibalize as appropriate. Peak cannibalization periods for a squadron

are predictable by the wing. Spare parts for many of the E-2C systems are in short supply and necessitate extraordinary action to overcome these shortages. To alleviate the shortages, the E-2C wing policy has become to cannibalize needed parts from returning deployed squadrons.

Example: A squadron returns from a six-month deployment. The first month is a stand-down period allowing sailors leave and adjustment time for administrative matters. Squadrons will normally only schedule flights to maintain proficiency, allowing aircrew to retain qualifications. Because of the light flying requirements, the returning squadron is considered the prime cannibalization squadron for the next deploying squadron. The E-2C wing is responsible for ensuring that a deploying squadron is as close as possible to fully mission capable (FMC). If a replacement part is needed and not available in the supply system, the wing will direct that stand-down squadron to remove the needed part from one of their aircraft and give that part to the deploying squadron.

This action causes a ripple effect. The squadron that surrendered the part completes a maintenance action form (MAF) to document the cannibalization. This MAF enters the supply system indicating that this squadron has a supply

problem; in reality, there may be no shortage of parts in that squadron, only a cannibalization directed by the wing. The MAF information is stored in a database. When reviewed by maintenance managers it will look as if the cannibalization was required when, in reality, it was directed. This scenario reverses itself for the receiving squadron. There is no documentation about the real problem of unavailable parts, because the requisition has been artificially filled.

Another option for the East Coast to acquire parts is using the E-2C training command. The training command has four times the aircraft of a normal fleet squadron. Because of these extra aircraft, the Atlantic wing has more choice about where they acquire a needed part.

The entire cannibalization process saps the morale and energy of the maintenance organization and, on some occasions, the practice may result in equipment damage, or worse. Cannibalization is a risky practice used far too often.

D. ALTERNATIVES TO CANNIBALIZATION

Cannibalization delivers to the maintenance manager a timely component that is ready for flight with minimum amount of effort. Cannibalization discounts logistic system

failures and allows the maintenance manager to work in an environment of low risk. Cannibalization can maximize readiness, help meet most, if not all, operational commitments placed on a squadron. However, at what cost do we continue to look at cannibalization as the supply remedy for logistic shortfalls? Cannibalization must be the last option in resolving supply shortage issues.

One alternative to reduce cannibalization, if readiness and operational commitments remain the same, is improve the logistic system to where MTBF data is accurate and reflected in the acquisition process. This assures users in the fleet that accurate spare levels are sufficient to support operational requirements. Sufficient parts provisioning results from realistic reliability analyses and is updated as necessary.

A second alternative is to reduce turnaround time of repairable parts. This simple option makes more parts available to the supply system. Buying enough spares is the correct first step, but that would only be a short-term fix if maintenance facilities cannot keep up. Reducing turnaround time of repairable parts and increasing spare stockage levels must work together to decrease cannibalization in the fleet.

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IV. READINESS/COST EFFECTS OF WARRANTY AND CANNIBALIZATION ISSUES CONCERNING THE E-2C AIRCRAFT

A. AN ANALYSIS

This chapter highlights and analyzes problems discussed throughout this thesis concerning the E-2C aircraft. The E-2C aircraft, as the fleet workhorse, is used in most tactical operations. It supports not only the airborne early warning community, but also drug interdiction and search and rescue. With so many duties, the E-2C is required to be ready when called upon, but readiness problems that have plagued the E-2C and naval aviation in general are taking their toll.

Information provided in the upcoming paragraphs will alert the reader to the difficulties involved with solving production and maintainability problems of an aging aircraft. This chapter reviews: the E-2C aircraft integrated logistical support concerns; readiness goals set by CNO and why they may be impossible to achieve; man-hour cannibalization costs; why manufacturers' warranty clauses may help cause aircraft cannibalization; readiness costs of the ASPA program; associated documentation problems; and how future E-2C decisions may affect fleet readiness.

B. INTEGRATED LOGISTICAL SUPPORT

An initial look at the E-2C suggests that the maintainability problems might be traced back to the beginning of the acquisition process. The E-2C community's reliability to meet established integrated logistical support (ILS) goals have contributed to the maintainability problem.

1. Reliability and Maintainability

The Department of Defense (DOD) has made acquisition reform a major priority in recent years. The aircraft acquisition process has been improved as managers have learned from past mistakes; now, reliability and maintainability are major design criteria in naval aircraft acquisition. Reliability is the probability that a system will perform in a satisfactory manner for a given period of time when used under specified operating conditions; that is, the duration of fault free performance. Maintainability is the ability to repair an aircraft in a given time period assuming trained personnel and proper replacement parts; it is described as the ability to restore an item to like-new condition.

The E-2C aircraft has relied heavily on reliability and maintainability engineering from the very beginning of

the acquisition process. However, this aircraft has one of the highest cannibalization rates among naval aircraft. Cannibalization can, in part, be attributed to an aircraft whose component parts fail prematurely or whose parts can be removed and replaced quickly (in most cases in less than 15 minutes elapsed time). In the view of the E-2C maintenance manager, waiting for the supply system to react to demand does not seem to be an alternative worth considering.

When the E-2C was introduced into the acquisition process, aircraft maintainability should have been a high priority. However, that was not the case. Aircraft systems tested during the development phase showed that reliability estimates were overstated. In other words, MTBF on many components were 50-60 percent less than anticipated.

The failure rates of the top 20 cannibalized components for the E-2C from January 1998 to December 1999 are presented in Table 4.1. The Maintenance Replacement Factor (MRF) along with the Rotable Pool Factor determines the component failure rate using a formula developed by NALDA. Failure rates are calculated by adding the MRF and RPF. The current failure rate is compared to the previous failure rate to determine whether the rate is increasing or

decreasing for those items. (Williams, 1997) Table 4.1, shows failure rates are increasing for 13 of 20 E-2C components. This means that the components are failing more frequently than estimated. Suggesting that insufficient testing was performed during the acquisition cycle or that poor test results did not result in redesign of faulty components.

Replacement parts are procured for new aircraft from data established during testing. If the data is inaccurate or ignored, planning data will be inaccurate. Spare parts procurement for the E-2C was 50-60 percent short of actual requirements. This explains why the E-2C has one of the highest cannibalization rates among naval aircraft. Although wing maintenance Master Chiefs recognize that aircraft are sometimes cannibalized for convenience, in the case of the E-2C, it is because of necessity.

ITEM	NIIN	Nomenclature	CANN Act #	DMMH	Previous Failure Rate	Current Failure Rate	Failure Rate Inc/Dec
1	01-407-4940	Circuit Card Assy	110	6319	****	****	****
2	01-014-4049	Digital Indicator	104	7218	0.080	0.125	Inc
3	01-029-4982	Air Nav Computer	67	5185	0.167	0.129	Dec
4	01-433-1555	Radio Receiver	66	1503	****	****	****
5	01-016-4134	Control Indicator	62	4625	0.115	0.203	Inc
6	01-022-1737	Trigger Amplifier	58	5719	0.248	0.281	Inc
7	01-408-0371	Azimuth Indicator	57	999	****	****	****
8	00-255-4094	Pwr Sup Amplifier	53	2599	0.070	0.301	Inc
9	00-882-3098	Memory Display	53	2538	0.141	0.428	Inc
10	01-386-9690	Comm Control	48	1577	0.100	0.739	Inc
11	01-382-0706	Transmit Receiver	44	1450	0.050	1.742	Inc
12	01-299-1542	Radio Set Control	44	756	0.003	0.610	Inc
13	01-411-3357	Display Unit	42	830	****	****	****
14	01-004-1604	Amp Converter	42	3882	0.043	0.234	Inc
15	01-079-4218	Inertial Measuring	39	6859	0	0.131	Inc
16	01-408-0375	EMDU Wiring Harness	38	2415	****	****	****
17	01-086-4200	Roll Computer	37	3534	0.063	0.246	Inc
18	01-443-7394	Sig Processor	37	1005	****	****	****
19	01-015-2282	Power Supply	36	2581	0.046	0.375	Inc
20	01-368-5778	RDR Receiving Set	36	835	0.006	3.05	Inc

Inc/Dec Denotes Increase or Decrease
**** Denotes data not available

Table 4.1 Failure Rates for Highest Cannibalized Items

During an interview with Commander (CDR) Roy Moore, Assistant Program Manager Logistics (APML) for the E-2C aircraft, he discussed program funding. CDR Moore, a professional logistician, who is knowledgeable of the E-2C acquisition, asserted that budget constraints were a causal factor for not buying sufficient spares to adequately support readiness goals. The budget will always be a factor in any acquisition process, but more so today.

In the 1980's, when funding for the E-2C Group II aircraft was appropriated, the military acquisition budget was at its highest level since World War II. What happened? Why did we not fix the problem in the 1980s when we had the money and opportunity to do so? The apparent answer: logistics has taken a back seat to operations. The acquisition process fields the system, then worries how to support that system later.

Insufficient logistical support is exactly what happened with the E-2C aircraft. Accurate reliability tests would have proven that MTBF of many of the E-2C components was a tenth of the contractor's reliability predictions. Logistics support must be emphasized early in the acquisition process to obtain the most reliable and

maintainable components possible. Then if testing or fleet data shows the MTBF of a component is higher than expected, adjust the spare requirement so that appropriate spare parts are procured to match the new parameter.

If government personnel used the null hypothesis to ensure failure rates were accurate and insisted that the contractor prove planned MFHBF rates, then E-2C aircraft would not be experiencing the problems that exist today. (Blanchard, 1998)

Program Managers (PM) are government representatives; they must ensure that government is purchasing the best possible product. Costs drive a program decisions. If the PM is under or at their budget cost for a particular program, their program is on track. If the program is over budget, it is off track which can cause program cancellation, or, in some instances, cause the Program Manager to lose his job. The PM feels extraordinary pressure to hold down cost and maintain schedule by letting the contractor off the hook on component reliability or maintainability. The PM is always concerned that technical problems will delay the program or increase program costs.

In reality, this is exactly where PMs should "earn

their paycheck." It is much easier and less expensive to solve a problem early and up-front in the acquisition process, before it becomes a fleet problem. Too many times, decisions to push a product through the developmental cycle cause unnecessary problems down-stream. Poor decisions to move ahead with suspect programs soon become problems for the technician who repairs or replaces components that fail prematurely. The remedy is to ensure that reliability achieves required standards. The cost, if reliability goals are not realized can be counted in degraded readiness, retention, and morale.

Retired Rear Admiral Donald Eaton put the logistic situation in focus in a document representing the feelings of many frustrated logisticians "Revolution in Logistic Affairs A New Strategy). Many of the observations presented in the paper seem reasonable. According to Admiral Eaton:

> Cultural change is the most important and most powerful step we can take to improve logistics in the 21st century. Overcoming cultural inertia is difficult. We can no longer afford to make bad logistics trade-offs early in a program and attempt to make up for them with increased labor at the operational unit or by the application of some ad hoc modification and hope it works. The cannibalization rates are higher than ever for even our newest airplanes. The hidden costs of increased labor by sailors, airman, and soldiers are enormous in terms of mission opportunity costs, reduced retention and mistakes in documentation, which distort the true readiness picture.

Our leadership's mindset about logistic support must change. Logistics can no longer take a back seat during the acquisition process, or throughout the lifecycle of any platform.

C. READINESS GOALS

Personnel shortages and rising maintenance costs have contributed to the E-2C maintainability difficulties over the past five years. The E-2C aircraft has difficulty maintaining the readiness goals set by CNO: 70 percent mission capable (MC) and 54 percent fully mission capable (FMC). Critical shortages of replacement components, logistical support, decreasing budgets, and shifting priorities across operational commitments all degrade readiness. Table 4.2 displays FMC and MC rates during the past five years for the E-2C Atlantic and Pacific fleets. Notice neither fleet attained the FMC goal set by CNO and only the Pacific, fleet was within the 70 percent MC rate. (OPNAV 5442.4M, 1990)

		FY95	FY96	FY97	FY98	FY99	Average %
Atlantic Fleet	%MC	71.9	66.6	66.5	69.7	69.7	68.88
	%FMC	51	53.4	49.1	40.3	40.3	46.82
Pacific Fleet	%MC	73.2	70.5	68.3	71.9	71.9	71.16
	%FMC	55.4	49.4	51	32.7	32.7	44.24

Source: AV-3M Aircraft Summary Report (A7049) March 2000

Table 4.2 E-2C Readiness Rates

D. MAN-HOUR COSTS

Cannibalization costs are reflected in both the added material costs of parts that are damaged or worn out prematurely due to frequent maintenance and the man-hour costs of performing repetitive maintenance. Removing and replacing parts twice for cannibalization increases maintenance man-hours. The two-year cost of the extra man-hours for both fleets is summarized in Table 4.3. From the data, it is apparent that we cannot afford to cannibalize continuously.

Aircraft	**Command**	**CANN ACT**	**DMMH**	**DMMH Costs**
E-2C	Atlantic Fleet	1,812	579,517	36,694,181
E-2C	Pacific Fleet	2,351	335,720	21,296,009
Total		**4,163**	**915,237**	**$57,990,190**

Source: LMDSS End Item/Claimant Report January 1998 to December 1999

Table 4.3 Total E-2C Cannibalization Costs

E. PROPRIETARY SERVICE REQUIREMENTS WITHIN MANUFACTURES' WARRANTY CLAUSES

The proprietary service requirements imbedded in contract warranty clauses cause concern in the E-2C community. Proprietary service allows only the manufacturers or contractor to repair their specific piece of equipment during the warranty period. Many E-2C systems

require contractor support because proprietary service written into the contract does not allow intermediate maintenance level support by military technicians.

Example: The E-2C aircraft Enhanced Main Display Unit (EMDU) is a vital piece of radar equipment that displays incoming air traffic on a video screen. The EMDU encompasses all the problems that have been discussed throughout this thesis. The actual MTBF for this component is half of the planned reliability according to COMAEWWINGLANT Maintenance Master Chief. (Barnes, 2000) Aviation Maintenance and Material Management (AV-3M) data reflect the fleet spent 1,218.40 man-hours cannibalizing the EMDU in the last 18 months. This component ranked number one for E-2C cannibalized parts based on man-hours. Yet, only half of needed spare EMDU's were purchased and available in the supply system. The chance of a "stock out" is very high when operational demands increase.

The problem: When a component needs to be replaced and a replacement is available in supply, maintenance personnel typically requisition another component from supply. However, because supply only carries half of the needed EMDU inventory, the part may not be available (Harvey,

2000). If the EMDU is not available in the immediate supply system, the squadron is forced to remove the bad EMDU from the aircraft and return it to AIMD for repair. However, the EMDU is a proprietary system, which is supposed to be repaired by a contractor from L3 Communications, a sub-contractor for the Northrop/Grumman Corporation. Normally delays ashore are minor; the contractor works at the local AIMD and repairs the EMDU when it is inducted into the supply system.

In contrast, the process becomes very complicated when a squadron at sea needs a replacement EMDU. Deployed aircraft carriers used to carry contractor personnel when deployed; since the defense budget drawdown, fewer contractors are deploying. Thus, the bad EMDU must be removed from the aircraft and prepared for shipment to the nearest AIMD ashore. The EMDU is repaired and shipped back to the aircraft carrier for disposition. For example, Atlantic fleet squadrons send the EMDU to AIMD Norfolk. This procedure, called repair and return (R&R), is time consuming and not very efficient when an aircraft needs a replacement component immediately.

In response to the inefficiencies of the R&R policy

for the EMDU, the Atlantic fleet E-2C wing formulated a plan to restructure the original contract. The new plan allows the contractor to train organizational and intermediate maintenance personnel in repairing the EMDU. By the end of fiscal year 00 the plan will be totally implemented. The new training procedure eliminates the need for the proprietary services contract clause, and improves EMDU turnaround time both ashore and afloat.

F. READINESS COSTS OF ASPA AND PDM SCHEDULES

Aircraft Service Period Adjustment (ASPA) inspection was developed to provide long term cost savings by deferring aircraft from depot maintenance. Naval Aviation Logistics Center (NALC) at Patuxent River, Maryland created the ASPA program in 1983. The program was developed to reduce Standard Depot Level Maintenance (SDLM) costs per aircraft (Eaton, 2000). In 1983, depot inductions were reduced from 720 to 420 aircraft and the Navy realized a one-time savings of $300 million. The ASPA program included an inspection conducted at the end of the aircraft Operating Service Period (OSP) to determine if depot induction was required. Each aircraft inducted into SDLM had a contract base cost of $1 million. The ASPA inspection

determined whether an aircraft could be extended for one year or should be inducted into the depot as scheduled. The squadrons prepared the aircraft and NADEP personnel conducted the inspection and determined if the aircraft could be waived from induction into the depot.

Over time, the ASPA program had adverse effects on the E-2C program. First, the NADEPs had difficulty in properly planning work for depot personnel because fewer aircraft were inducted than were scheduled. Second, lack of regularly scheduled maintenance gradually reduced the demand for parts from the supply system resulting in reduced spare parts stockage levels. Third, it was common to extend an aircraft for three to five years, increasing the number of problems each aircraft had when it finally arrived at the NADEP. This increased dispersion of the required repair time. Fourth, ASPA lengthened the time required for an aircraft to complete SDLM, because the depot had to inspect each aircraft to identify problems before they could order the needed parts. Each aircraft inducted had different problems. With the ASPA program, Standard Depot Level Maintenance was no longer "standard." Long lead times were required to obtain needed parts to

complete aircraft maintenance. As a result, depots cannibalized new inductees to repair aircraft completing SDLM and return them to the fleet. (Griffea, 1998)

During the 1990's, ASPA was no longer an issue for the E-2C. Aging aircraft and increasing electrical wiring issues caused the fleet to request that NADEP North Island (NI) induct more E-2C aircraft into SDLM. The request caused a rework backlog of almost two years for NADEP NI, because more than 20 percent of the current E-2C aircraft were already overdue for SDLM induction, according to the Atlantic, type wing assistant maintenance officer. (Lawson, 2000)

Despite the rework backlog, aircraft were still being scheduled for ASPA inspections because the aircraft were reaching the end of their operating service period. This new dilemma caused NADEP inspectors to grant ASPA aircraft a one-year extension; there was insufficient capacity at NADEP NI to induct them. However, the extension cost the squadron hundreds of man-hours in repair and cannibalization. The NADEP inspectors averaged well over 300 maintenance discrepancies per aircraft inspection. Many of the discrepancies were categorized as critical, meaning

they had to be repaired before releasing the aircraft as safe for flight. A typical fleet squadron takes, on average; over six weeks of dual-shift maintenance to remove discrepancies from an ASPA inspected aircraft.

In the end, the ASPA program started a vicious cycle that reduced the spare part stockage level, due to low demand data, and increased reliance on cannibalizations to get operational aircraft to the fleet.

1. Phase Depot Maintenance

Phase Depot Maintenance (PDM) is a Navy concept developed to mirror the Air Force and airlines' rigid periodic depot maintenance and planned depot maintenance programs, respectively. Phase Depot Maintenance, developed to replace the ASPA program, incurred the same problems as the original ASPA program: slipping induction dates and NADEP backlogs. In the Air Force program, aircraft are inducted as scheduled on a set time based solely on calendar time. The difference between the two programs is that the Air Force and airlines have short depot turn-around times, usually less than 90 days (and for the airlines as short as a week), while the Navy program consistently exceeds 18 months.

In the Air Force and airlines' system, no waivers are granted. When an aircraft is scheduled for induction into either system, the aircraft is sent to the depot for rework as scheduled. Wide time dispersions are not a problem in these systems because each aircraft arrives with the same time period between scheduled maintenance periods. Rework variance of 100-200 maintenance man-hours is normal, compared to 20,000-30,000 man-hour variances for a typical E-2C aircraft coming in for rework. It is easy to see why the Navy has SDLM backlogs and part shortages.

The airlines cannot afford to have a 747 out of commission for over 90 days; the airline would lose too much revenue. The Navy needs to think about their phase depot maintenance system in the same way: not as… a profit making business for the NADEP but for what it can save the Navy in overall efficiency and reduced SDLM costs. Changing the Navy concept might be a burden at first, but it would save the Navy time and money with improved products and increased readiness.

G. DOCUMENTATION

There were many inconsistencies in the data collected. Data from the Logistic Management Decision Support System

(LMDSS) reports varied significantly from AV-3M reports that came from the NALDA database at NAVAIR. Many of the requested reports provided conflicting information. Cannibalization data extracted from COMAEWWINGPAC cannibalization spreadsheet differed greatly from the data stored in the NALDA database. COMAEWWINGLANT used cannibalization data provided by individual E-2C squadrons under their control. Although the Atlantic fleet data differed from the NALDA database, the wing indicated individual squadrons provided the most accurate and useful cannibalization information. However, NALDA is supposed to construct its database from squadron reports submitted monthly to a central depository. Data provided in the monthly reports is assembled, analyzed and then distributed among the many NALDA databases.

Inconsistencies between databases make it almost impossible, to extract accurate information. Maintenance managers make important decisions based on NALDA data; it is in the best interest of all concerned to provide information that is as accurate as possible. For example, a visit to COMAEWWINGLANT indicated the need to develop one data source that archives all AV-3M data and tracks

cannibalization trends. A database that automatically prompts inventory management activities to update failure rates and makes necessary procurement adjustments to reflect real time material shortages and component shortfalls would eliminate the need for multiple databases. This would create information that is much more reliable for the user.

H. FUTURE E-2C DECISIONS

The program office has another opportunity to correct readiness shortfalls while introducing the next generation E-2C aircraft, The Hawkeye 2000. CDR Moore, E-2C APML, indicated that the Hawkeye 2000 is a production aircraft, but it shares many systems with the E-2C Group II aircraft. Both aircraft use the APS-145 radar, a radar system that is presently 11 years old with documented reliability weakness. If the APS-145 radar is installed in the Hawkeye 2000, with the same problems as previous versions of the E-2C aircraft, this will prolong existing fleet radar maintenance problems until the scheduled radar system replacement in 2015. By the time the APS-145 radar is retired, it will have served in the E-2 aircraft for over 26 years, still exhibiting problems that originated in the

1980s. Defective designs not corrected during the original development process over 20 years ago are still prevalent today. The E-2C will continue to incur problems with manufacturers' warranties and cannibalization issues if the E-2 community does not take a more active role in resolving these widely recognized problems.

V. CONCLUSIONS AND RECOMMENDATIONS

A. OBJECTIVES

This thesis analyzed both cannibalization and warranty issues and their effect on the E-2C aircraft. The analysis included warranty and cannibalization structures for the Pacific and Atlantic fleets, and personnel and readiness costs. This thesis examined the impacts of manufacturers' warranties and aircraft cannibalization on the maintainability of the E-2C aircraft.

B. CONCLUSIONS

The following are the conclusions of this research:

As described in Chapter II:

1. Manufacturers' warranties do contribute to aircraft cannibalization. Reliability and maintainability warranties help determine spare stockage levels. This thesis determined that inaccurate R&M estimates created stockage shortfalls in many of the top cannibalized components of the E-2C.

As described in Chapter III:

2. Shortages in the supply system and slow response times are a major cause of cannibalizations.

3. Increased operational commitments force squadrons to cannibalize due to shortages of available parts.

4. Cannibalization causes repetitive maintenance and is costly. It depletes resources that could be used for other maintenance/activities.

As described in Chapter IV:

5. Introducing production aircraft to the fleet without proper logistical support increases aircraft cannibalization and decreases readiness.

6. The ASPA and PDM programs delay scheduled maintenance, resulting in the total failure of some components, consequently increasing the overall cost and time of SDLM inductions.

7. There were many inconsistencies among the different data sources. Logistics Management Decision Support System (LMDSS) and Naval Aviation Maintenance and Material Management System (AV-3M) reports came from the NALDA database, but provided conflicting information.

C. RECOMMENDATIONS

The following are recommendations from this research:

1. Develop an acquisition strategy where logistics is given appropriate priority and attention. Too many times

logistics is secondary when establishing milestones, but it is the first option used when budget cuts occur.

2. Minimize cannibalizations and only use to meet critical operational commitments. Cannibalizations should not be used simply for convenience or to increase aircraft readiness.

3. Minimize the use of proprietary service within manufactures' warranties to permit repairs by the technician in the fleet. We cannot expect expeditious component repairs if we do not give the technician adequate opportunities to make repairs that they are trained and equipped to do.

4. Adjust the ASPA and PDM programs to mirror the commercial airlines' programs. Do not grant waivers or extensions when aircraft exceed their operating service period. This will tighten dispersion in depot turnaround time and decrease labor costs.

5. Withhold introducing new aircraft systems to the fleet until shared legacy systems are supported properly, thereby decreasing cannibalization and increasing readiness.

6. Establish one data source that historically

archives all Aviation Maintenance 3M data. NALDA databases, continuously updated, have made great improvements for extracting data. However, cannibalization trends in this database should automatically prompt inventory management activities to update failure rates and make appropriate procurement adjustments.

APPENDIX. ACRONYMS

The following is a list of acronyms as they are used in this thesis:

AEW	Airborne Early Warning
AIMD	Aircraft Intermediate Maintenance Department
AMRR	Aviation Maintenance Readiness Reports
APML	Assistant Program Manager Logistics
ASPA	Aircraft Service Period Adjustment
AVCAL	Aviation Consolidated Allowance List
AV-3M	Aviation Maintenance, Material, and Management
BIT	Built in Test
CNAL	Commander Naval Air Force Atlantic
CNAP	Commander Naval Air Force Pacific
CNO	Chief of Naval Operations
DMMH	Direct Maintenance Man-hours
DOD	Department of Defense
ECP	Engineering Change Proposal
EMDU	Enhanced Main Display Unit
FMC	Fully Mission Capable
ILS	Integrated Logistical Support
LMDSS	Logistic Management Decision Support System
MC	Mission Capable
MCMT	Mean Corrective Maintenance Time

MFHBF	Mean Flight Hours Between Failures
MRF	Maintenance Replacement Factor
MTBF	Mean Time Between Failures
NADEP	Naval Aviation Depot
NALC	Naval Aviation Logistics Center
NALDA	Naval Aviation Logistics Data Analysis
NAMP	Naval Aviation Maintenance Program
NAS	Naval Air Station
NAVAIR	Naval Air Systems Command
NAVICP	Navy Inventory Control Point
NMCS	Non Mission Capable Supply
OSD	Office of the Secretary of Defense
OSP	Operating Service Period
PDM	Phased Depot Maintenance
PM	Program Manager
PMC	Partially Mission Capable
PMCS	Partially Mission Capable Supply
R&M	Reliability and Maintainability
RFP	Rotable Pool Factor
SDLM	Standard Depot Level Maintenance
VIDS/MAF	Visual Information Display/Maintenance Action Form

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